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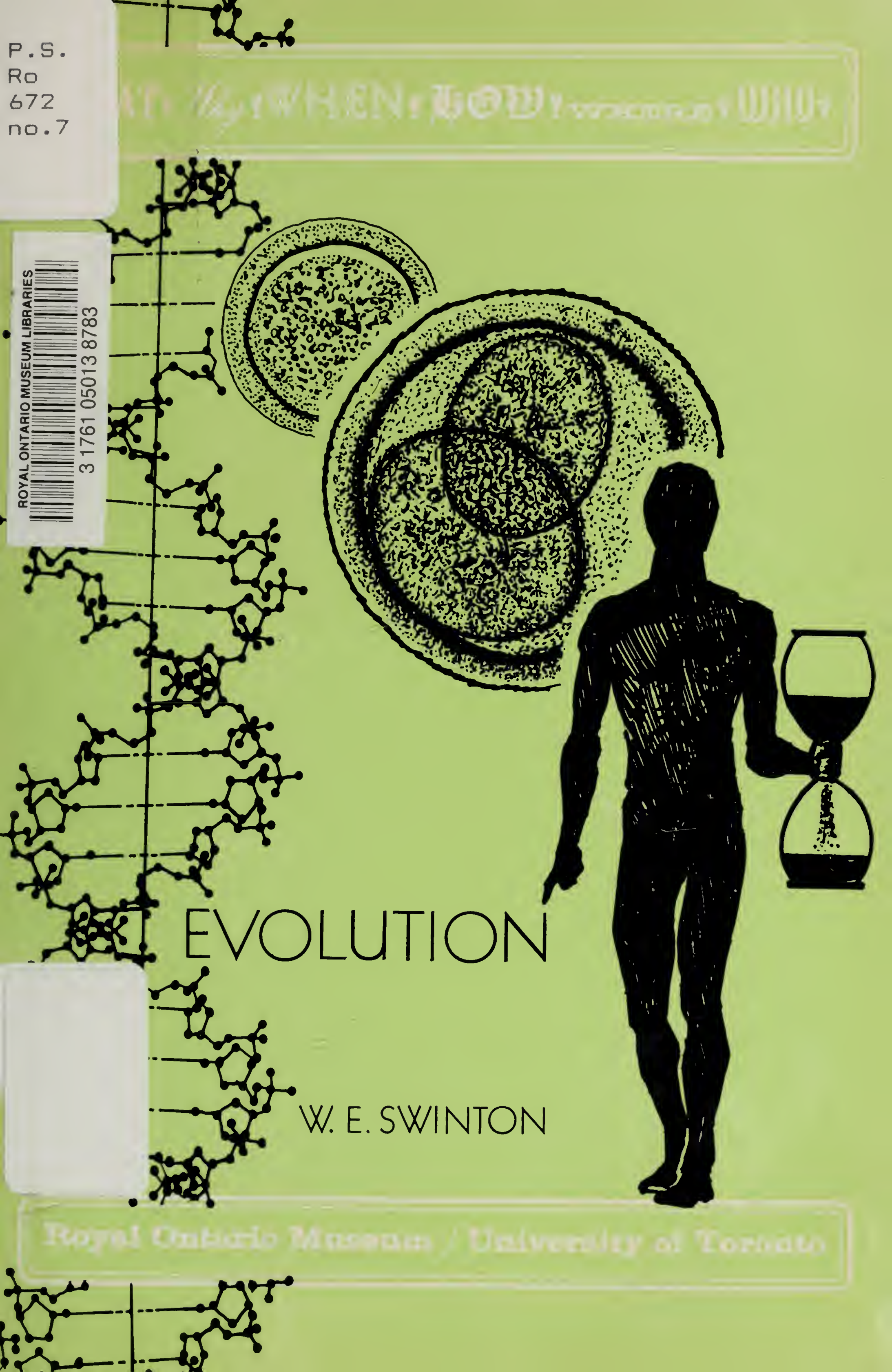

EVOLUTION

W. E. SWINTON

Royal Ontario Museum / University of Toronto

I keep six honest serving-men
(They taught me all I knew);
Their names are WHAT *and* WHY *and* WHEN
And HOW *and* WHERE *and* WHO.

RUDYARD KIPLING

ROYAL ONTARIO MUSEUM SERIES

WHAT ? WHY ? WHEN ? HOW ? WHERE ? WHO ?

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4 *R. R. H. Lemon:* FOSSILS IN ONTARIO
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14 *K. B. Brett:* WOMEN'S COSTUME IN ONTARIO (1867–1907)

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WHAT? HOW?

Why? WHERE?

WHEN? WHO?

Evolution

by W. E. SWINTON

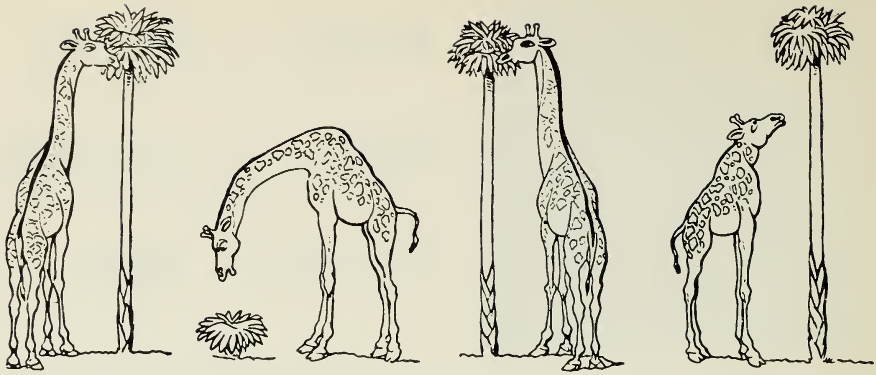
WHAT is evolution?

Evolution means unfolding or opening out. It thus can mean the unfolding of a story or history, the appearance of events in succession. It can mean, as the dictionary will show, the development of what is contained in an idea or principle; or the development of something from its rudimentary or imperfect state to the mature or more complete state.

History shows us many examples of these things. There has been an evolution (or development) of beds and bicycles, streets and houses, lighting and transport. Few of us live as our most remote ancestors did, clothe ourselves as they did, eat the food that they enjoyed or speak the language that they used. We accept these facts and call the result progress, though this is just another name for evolution too.

An ordinary English dictionary will add a further definition—"origination of species of animals and plants *by process of development from earlier forms*". Note the words in italics.

A scientific dictionary will be more precise in its definition and will say something like this: "The gradual development of organisms from pre-existing organisms since the dawn of life." This is a comparatively simple statement that has, none the less, important implications. It means that evolution is concerned with the development of life, not with the creation of life; that the organisms or groups of organisms in which we see such development have always been the descendants of other living things. Just



—Tell me, Dad, why *are palm trees so tall?*
—It's so the giraffes can eat them, my child, for . . .

if palm trees were quite small, the giraffes would be very embarrassed.

—But then, father, why do giraffes have such long necks?
—Well, it's so that they can eat the palm trees, my child, for . . .

if giraffes had short necks they would be even more embarrassed.

A FRENCH CARTOONIST'S VIEWS ON SOME OLD IDEAS ABOUT EVOLUTION

as we do not see human or animal babies coming from any source other than their parents, which are or were living things much like the offspring.

If we are ready to accept that almost everything we do is done differently from the ways of our remote ancestors, why should we think that life has always been the same, that the same animals and plants have existed from the beginning of time in the same form?

Several answers can be given to that last question. Perhaps we are insufficiently acquainted with the life of the past to know what differences have taken place over the ages. Perhaps we cannot see much change in the animals and plants around us. Yet geologists, palaeontologists (students of past life), botanists and zoologists, entomologists, and animal and plant breeders all attest to the fact that change has always been a characteristic of life and its environment.

Many wanderers over the earth's surface and even simple investigators into the seas have wondered at the differences they could see. Why are animals found in one part of the world and not in another? Why aren't elephants native to Canada? Why are some kinds of lung-fishes found only in South America, South Africa and Australia? Were these southern tips of land once connected?

Charles Darwin, when a young man travelling in South America, wondered why the bones of fossil animals to be found there differed from the animals he saw living on the pampas. Why had the old kinds disappeared and where had the new ones come from? Alfred Russel Wallace observed the remarkable distribution of animals in the Dutch East Indies. Some were like animals of Australia, others like those of Asia. How, when and why had the geographical division and distribution come about?

Many animals of somewhat similar habit and appearance are not at all related—like the dolphin (a mammal) and the shark (a fish). How are these similarities attained?

Men from ancient times (Aristotle, for example, 384–322 B.C.) wondered about things like that and recorded their thoughts, though hardly any of their questions were answered until about a hundred years ago. Throughout the centuries there were two points of view. One, that all the animals and plants were created when the world was first made (and this was the majority view): the other, that during the long history of life new kinds of life had gradually been developed from the old to add to the population.

WHO discovered organic evolution?

If this question were asked of the so-called man in the street one or two replies would almost certainly be given. They would be that "Darwin invented or discovered evolution" and that the principal feature of evolution, according to Darwin, was "that men were descended from monkeys". Both these statements are completely false.

Organic evolution is that form of evolution particularly associated with life, or organisms, whether animal or plant, living or fossil.

The word evolution has long been used in the sense of unfolding or of general development, but in the more restricted sense of growth of parts of animals it dates from 1670. (*Philosophical Transactions of the Royal Society of London, V*, p. 2078.) Charles Bonnet, the Swiss naturalist was, however, the first person to use the word evolution in the sense that we now use it, though his understanding of the process was inaccurate. He used it in 1762 (*Considerations sur le corps organisés*, Geneva).

The concept of origination of species also has a long history. Charles Darwin's great book *The Origin of Species by means of natural selection*, published in November 1859, might seem to suggest itself as the main source of the idea. In fact Charles Darwin, when a medical student in Edinburgh in 1826, attended lectures on "The Origin of Species" given by one of his professors.

It was towards the end of the 17th century that John Ray, the English naturalist (1628–1705), first pointed out that animals and plants consist of natural kinds or species which he defined as groups of individuals "that breed among themselves". A classification of the kinds of plants and animals was attempted by Carl Linnaeus (1707–1778), the Swedish naturalist, in 1753 and 1758 respectively. Thus living things were already beginning to be studied scientifically and to be classified, but the cause of their abundant variety was still in doubt.

Ideas of Aristotle, held much later by the French scientists Pierre Louis de Maupertius (1698–1759) and Georges-Louis de Buffon (1707–1788) and by Charles Darwin's grandfather, Erasmus Darwin (1731–1802), were widely described by Jean Baptiste de Lamarck (1744–1829), namely that the effects of use and disuse on an organ or body could be directly inherited by the offspring. This is the inheritance of acquired characteristics and Lamarck thought they could be acquired if the animal needed them in its struggle with the environment. By the early 19th century several English writers (notably W. C. Wells, M.D., and Patrick Mathew) saw that a process of *selection* was involved and in 1831 Mathew actually called the process *Natural Selection.*

Darwin (1809–1882), as a result of observations during a world-wide voyage in the surveying ship H.M.S. *Beagle* and a subsequent lifetime of investigation, was able for the first time to explain the process, though one important part of his explanation, as we shall see, was incorrect. Alfred Russel Wallace (1823–1913), as a result of his travels and studies, came to the same conclusions at the same time. Darwin's book, *The Origin of Species by means of natural selection*, contained his explanations but we have seen that he did not invent the theory or the words *evolution*, *origin of species* or *natural selection*. And his book contains only 13 words about the origin of man—speaking of the future he says, "Much light will be thrown on the origin of man and his history".

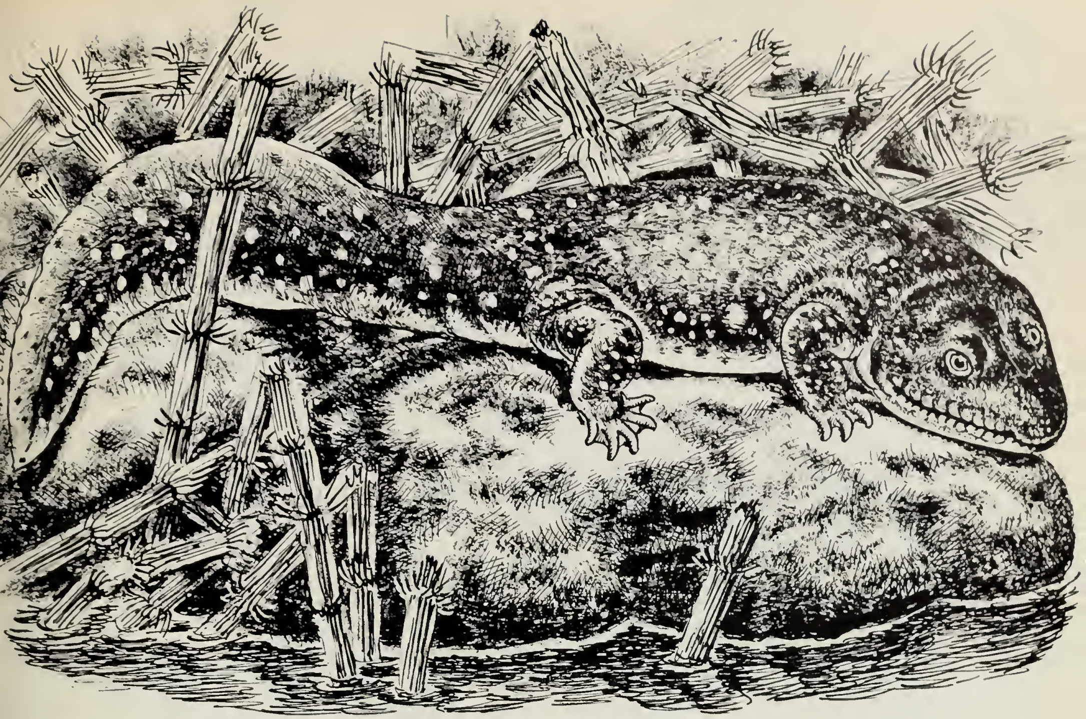
Since Darwin's day thousands of scientists have amplified the evidence and the explanations and believe firmly in the scientific truth of evolution.

WHERE is evolution seen?

In the second chapter of the *Book of Genesis*, verse 19, are these words, "And out of the ground the Lord God formed every beast of the field, and every fowl of the air; and brought them unto Adam to see what he would call them: and whatsoever Adam called every living creature, that was the name thereof."

This verse implies that all mammals and birds were created much at the same time and stresses the importance of names for them. Alas, the names that Adam gave have long been forgotten. Linnaeus was the first to attempt scientific naming, so that all students should know precisely what was being written about or discussed. His *Systema Naturae* had many editions but by general consensus the tenth edition (1758) is regarded by scientists as their nomenclatural foundation.

Linnaeus opened the volume with a scheme of classification in which God was apart and the Animal Kingdom consisted of Mammals (including Man); Birds; Amphibia; Fishes; Insects and Worms. He included the



BETWEEN FISH AND AMPHIBIAN: *An Ichthyostegalian*

From the fossil remains of prehistoric animals, we now can trace the evolutionary linkages between the separate classes of vertebrates. The four animals shown on this and succeeding pages are not prepossessing. Yet they are extremely important. Each combines characteristics of two classes—one already well established, the other yet to come into its own. They are thus "halfway houses" in the slow, step-by-step progress of life on land.

The first land creatures were, paradoxically, fishes. During the later stages of the geological period known as the Devonian, about 370 million years ago, there were frequent periods of drought when the freshwater pools dried up. Many fish were killed—but certain kinds could survive for some time because they had air-bladders or "lungs". One kind of lung-fish also had stout fins and fin supports and was able to move about in search of water. A modern, but somewhat altered, descendant of this kind of fish is the Coelacanth of East African waters.

While moving about on the broad bases of their fins, the Rhipidistians (as these early lung fish are named), were able to eat other fishes and thus survive when most of their freshwater contemporaries were dead. In this way backboned animals accidentally became land-living. Their descendants became fish-amphibians.

The Ichthyostegalians are known by specimens from Quebec and from Greenland and show a remarkable mingling of fish and amphibian characters, though they are to be classed as amphibian. They illustrate in their skulls and skeletons how the fish-amphibian transition was effected.

reptiles in the Amphibians, and among the Worms were all the shellfish, crabs, starfish, anemones, and more humble animals without backbones (invertebrates) that we now know by other classifications. Linnaeus named each species with two words, as in *Homo sapiens* for living man.

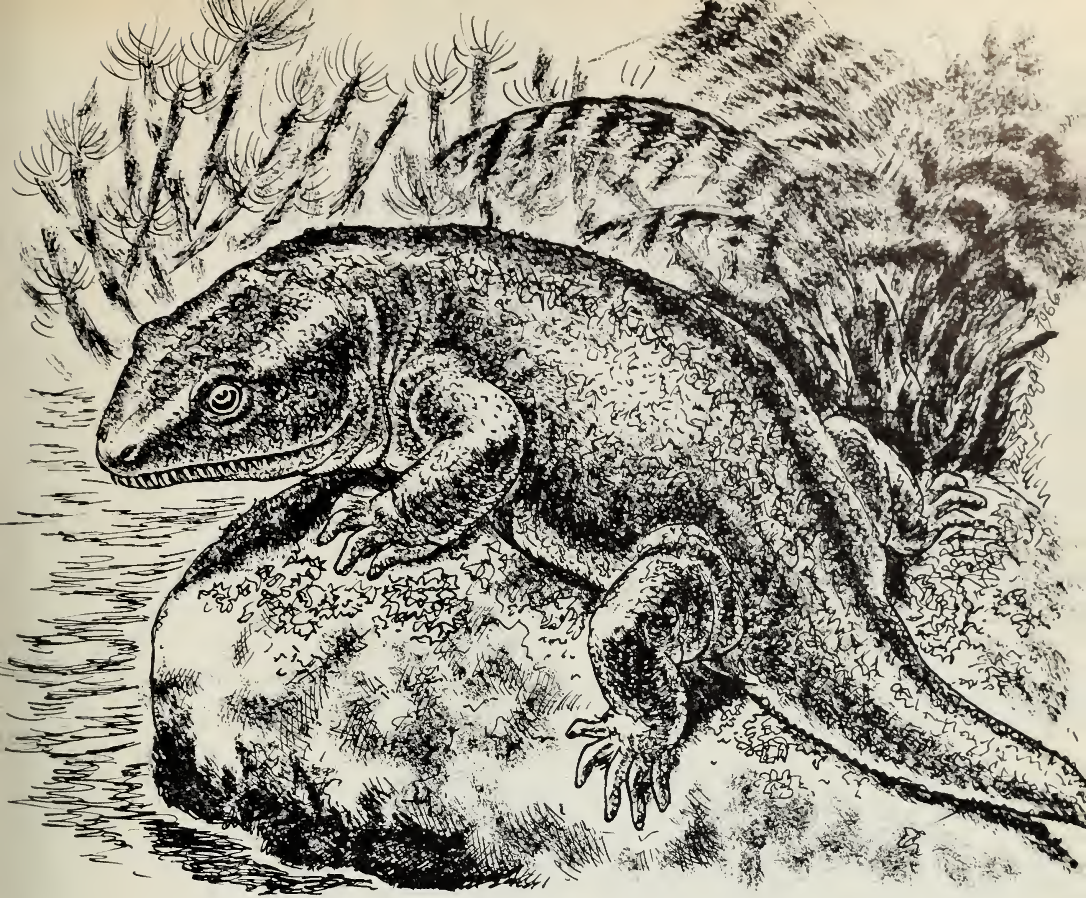
If we set out the classification horizontally—Mammals, Birds, Reptiles and Amphibia, Fishes, and Invertebrates from Echinoderms downwards—we find that from left to right they fall into descending order. The mammals, including the great apes (primates) and man, are by far the most highly organized creatures known, while to the right in varying and lessening degrees of complexity we proceed to the simpler and simplest animals, though none is, in fact, physiologically simple.

The successors of Linnaeus soon established the general correctness of this system but the width of it has been greatly increased by the discoveries of explorers, zoologists and microscopists. Life is far more numerous in its forms than Linnaeus could have dreamed.

Now if the story in Genesis is correct all these animals have existed side by side since the beginning of the world.

However, in the two hundred years since Linnaeus, discoveries of a different kind have been made in great numbers too. Long before Linnaeus, ancient philosophers knew that remnants of things which apparently had once been alive were occasionally discovered in rocks. Aristotle had theories about them, and Herodotus described sea-shells found far from the sound or sight of any sea. Mediaeval doctors sometimes considered them the remains of animals or people drowned in the flood. Eventually observers in England such as William Smith (1769–1839), who published the first geological map of England in 1815, established that strata (beds) of rocks could be identified by their fossils. In France, Georges, Baron Cuvier (1769–1832), worked earnestly to establish the value of fossils and by linking their evidence to that of comparative anatomy and zoology, he became the founder of vertebrate palaeontology. The last century and a half has seen the growth of all branches of palaeontology and palaeobotany to a remarkable degree. Fossils, a name derived from the Latin *fossilis*, "dug up", add the fantastically great range of the past to the present of zoology and enable us to see the march of life through time. And what does it show? It shows that the classification that we discussed horizontally, from left to right, can also be demonstrated from fossils from above to below.

In other words, man can be traced only a little way back in time; the mammals extend much further but they and the birds disappear too eventually, the reptiles being for long the dominant land-living, flying and swimming animals. Then they too disappear in the past and the amphibians predominate. Before them, the fishes were the most widespread and most important backboned animals, and going still further back in the rocks we can see layer after layer, representing aeon after aeon of time, in which



BETWEEN AMPHIBIAN AND REPTILE: Seymouria

This is a small lizard-like amphibian which is well known from rocks of Lower Permian Age (260 million years ago) at Seymour, Texas. The skeleton shows such a mixture of amphibian and reptilian characters that many scientists believe it to be a reptile. The only certain way to determine the matter would be to find an egg of the animal, provided one could be sure it was a Seymouria *egg. Amphibian eggs, laid in water, are significantly different from reptile eggs which are always laid on land.*

Despite all this, Seymouria *is too late in time to be the ancestor of reptiles, for true reptiles are known from the previous geological period. It is probably a remnant of a group that perhaps provided the ancestor, and its skeleton clearly shows how that ancestry was brought about.*

there were no backboned animals at all and the dominant creatures were kinds of starfish, crabs or shellfish. Back as near to the beginnings of life as we can get, are small creatures and primitive, often one-celled, seaweeds.

If we retrace these steps we find that in the beginning life consisted of simple animals living in the sea; later more complex sea-living animals are

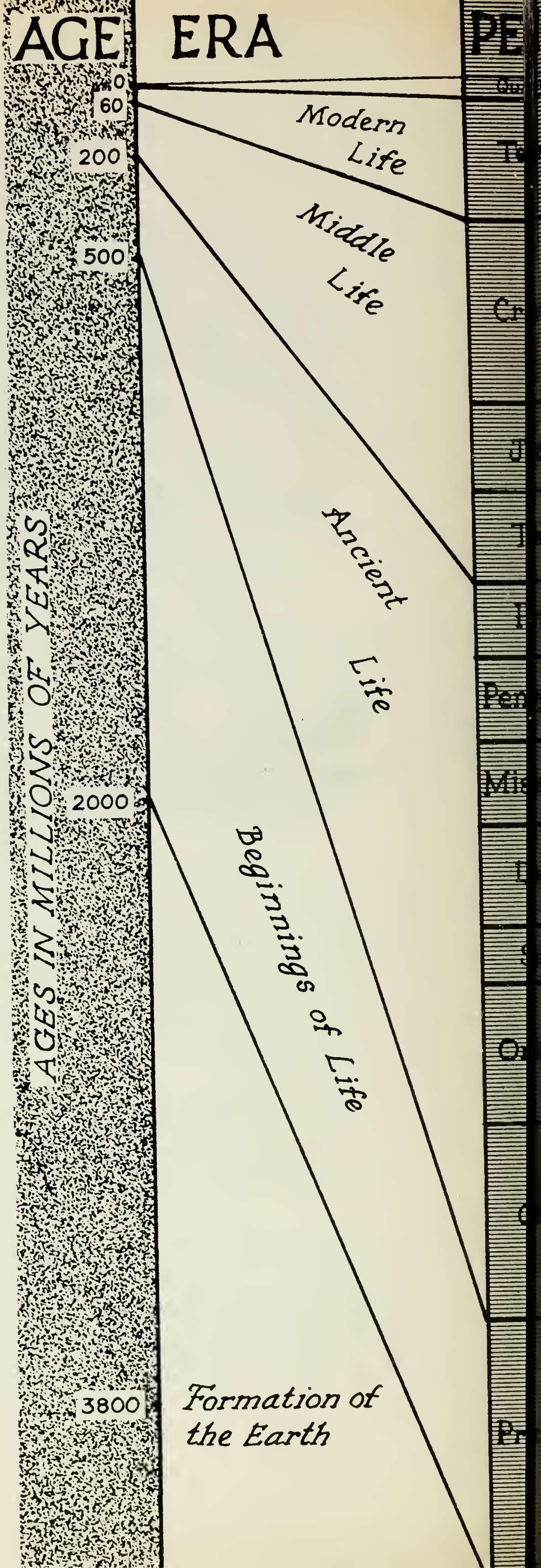
THE GEOLOGICAL PERIODS AND THE AGES OF LIFE

The table shows examples of the evidence of life in the rocks. If evolution were not a fact, the animals from beginning to end would be of the same kinds. The older palaeontologists (like Baron Cuvier) explained the facts by suggesting that series of catastrophes had occurred, during which life was wiped out and new creations were added. The fossil series are now so extensively known that lines of descent can be traced without recourse to such theories. There is no proof whatever of any special creations during the geological record.

Populations changed, dominant forms arose and faded or disappeared, great groups like the dinosaurs evolved and millions of years later became extinct. What is seen, is that as the years passed successively higher *forms developed until the warm-blooded mammals and man himself came upon the scene.*

Not all animals evolved into higher forms. Thus, fishes are abundant today although millions of years ago one particular kind of fish evolved the first amphibians. Reptiles are still represented in the modern fauna, though millions of years ago they were already very numerous and some kinds gave rise to both birds and mammals.

The table shows how dominance *changes and suggests that dominance itself does not persist.*



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LIFE

Ice Age

Age of Early Modern Animals

Age of Grazing Animals

Age of Giant Mammals

Age of Early Horses

Late Dinosaur Age

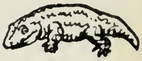
Middle Dinosaur Age

Early Dinosaur Age

Age of Early Reptiles

Age of Coal Swamps

Age of Amphibians

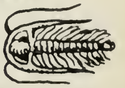


Age of Fishes

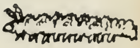
Age of Water Scorpions

Age of Giant Molluscs

Age of Trilobites



Age of Worms & Sea Weeds



Beginnings of Life

found, many with shells; then primitive fish-like forms are found in the waters; then plants and invertebrates invade the land; and in the freshwaters near the land the first amphibians emerge, also invading the shores. Later, reptiles are found at a time when luxuriant vegetation and alternating floods laid between them the foundations of the world's coal deposits. Then onwards and upwards, until the great spread of the reptiles made one of the most spectacular epochs in the world's history. Out of this came not only the reptiles as we know them now but the mammals and the birds that are now familiar. Nearly two million years ago, and only then, appeared the earliest men whose remains can be positively identified.

From this well-established story, supported by millions of fossils and the writings of thousands of scientists, we find that life has not always been the same. Man, mammals, birds and so on have not marched side by side through time. We find that great groups of animals have grown, have become established, and have died without descendants of any kind. We see the first appearance of great classes of animals like the fishes, the reptiles, the birds and the mammals. How did they arise? How are they connected?

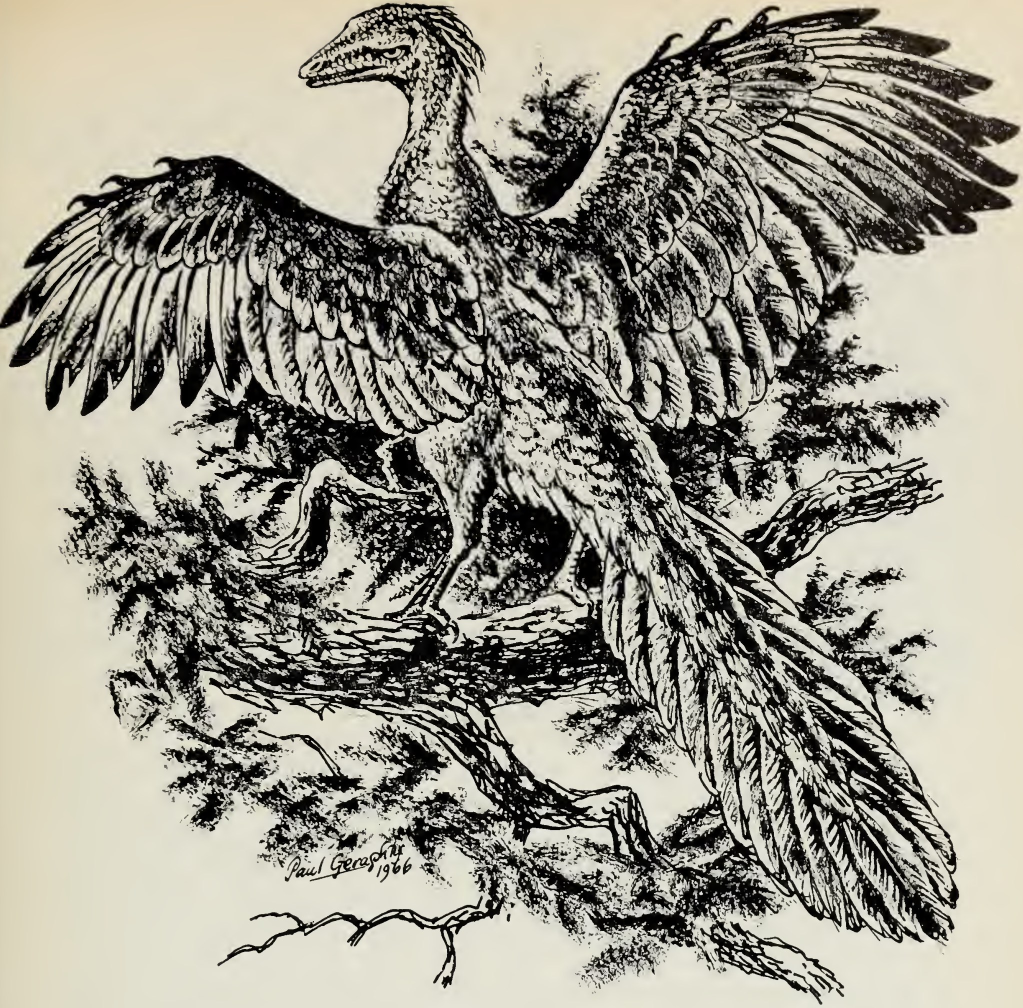
The critics of Darwin's theory of the inter-relationship of living things demanded to know where the *missing links* were between the backboneless and the backboned animals. How could that gap be bridged? Where were the links, if in fact there ever had been any, between fish and amphibian, amphibian and reptile, reptile and bird, and reptile and mammal; and, most fiercely argued point of all, where were the ancestors of man?

It can now be said that we know the linkage, if not every single link, in these apparently disconnected series. They amply illustrate the evolution of new groups from old, the effects of natural selection on living things.

The fossil record is long drawn out, and though far from complete it can be studied in quite remarkable detail. Among living animals and plants *variation* can be seen. To this we must add the evidence of the so-called sports-of-nature, the sudden and spontaneous variations from the normal which include, of course, not only advantageous structures, but also the monsters and the physically deficient or handicapped animal or malformed plant. Embryology also gives valuable evidence.

HOW does evolution work?

It is not easy to give in the few words available in this handbook anything more than the sketchiest outline of the remarkable and complicated processes by which evolution is brought about. The fossil record, the variation to be found in living animals and plants, adaptations of various kinds (some moths, for example, gradually change their light colour to black when they live in an industrial and smoky environment), and the effects



BETWEEN REPTILE AND BIRD: Archaeopteryx

The earliest bird is known from a feather and three skeletons, one in London, one in East Berlin, and one in southern Germany. All were found in a very fine-grained limestone that used to be quarried extensively for printing purposes near Solnhofen, Bavaria, Germany. They are Upper Jurassic in age, about 150 million years old. All have been studied intensively and show that the skeletons are quite reptilian. The skull, though it contained a bird-like brain and had many of its bones arranged as in a bird, had toothed jaws. The bones of the reptilian hand were elongated to carry the wing feathers, and in the foot the big toe was turned backwards to form a grasping structure. None of the bones had air cavities as in modern birds. In short, Archaeopteryx *had a reptile skeleton but with feathered wings. Even the tail was reptilian: it had bones in it with the feathers arranged along the length.*

Archaeopteryx *clearly shows that birds are descended from reptiles, it gives clues as to which kind of reptiles were involved, and it provides valuable evidence on the origin of flight.*

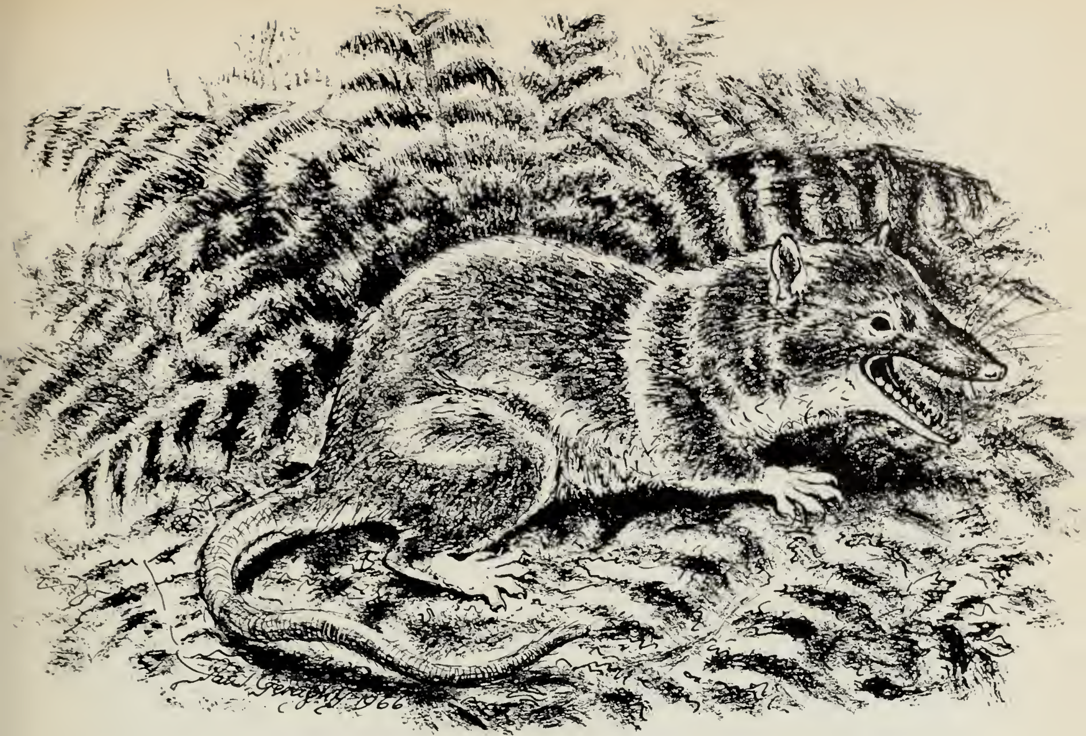
of artificial and natural selection, all attest to the processes at work on a long-term or short-term basis. A certain number of important factors can, however, be established.

Evolution occurs in populations of individuals and these individuals will vary from one another to some extent. Any species has a normal range with an estimable amount of variation: men, for example, normally may be five to seven feet in height but not three to ten feet. Species of all kinds show ranges with greater or lesser degrees of variation. Variation can be of colour (moth and butterfly wings, bird feathers), ornamentation (spines or spikes as in seashells), number of parts (arms of starfishes), or shape (of shells or skulls, for example). Some variations are due partly to changes in the environment (climate, soil, food, available space), and although these may have vital effects on the individual animal or plant, these particular variations will not be transmitted to the offspring. That is, they are not inherited.

Other variations carried in the *genes* of an animal or plant will produce variations that are inherited and are thus of evolutionary importance. These can be proved by experiments, such as the breeding of plants or animals.

To understand this kind of variation and the basis of evolution it is necessary to understand the living cell and its contents. Nearly all plants and animals (including human beings) are composed of *cells* which are the "bricks" with which any "house" of life is constructed. The cells themselves contain a complex substance called *protoplasm* which, though variable in composition, usually consists of water, proteins, carbohydrates, fats, salts and especially nucleic acids (DNA and RNA). When growth takes place and a cell multiplies it does so usually by division, so that the contents are shared between the resultant new cells. This division does not apply only to the protoplasm. Cells have a control centre or nucleus that is part of the protoplasm but contains a number of microscopic worm-like or thread-like filaments called chromosomes. Although small, these filaments readily absorb some dyes (the name means "colour-bodies") and so can easily be seen and counted under a microscope. The number is constant for different species of plants and animals; for example there are 23 pairs in human cells, 13 pairs in frog cells, and in some insect cells there may be thousands.

Chromosomes all carry, in sequence along their length, the genes which control all the hereditary characters of the organism. Hundreds of genes may be contained in a single chromosome. At cell division, the chromosomes split so that the daughter cells each receive the normal number of chromosomes and presumably of genes. Sometimes, however, a single gene is not doubled exactly, so that a slight change, or *mutation*, occurs and these new forms can go on reproducing their new state. Such mutations are the basis of hereditary variation, and consequently of evolution. They are due to chemical factors or instability in the cell, not to any



FROM REPTILE TO MAMMAL: Phascolotherium

In the late Triassic and early Jurassic (190–175 million years ago) there lived small furry animals of the size and shape of rats or shrews. Of course, no trace of their skin now remains but it is possible to deduce that they were fur-bearers. What is interesting and peculiar is that they were reptiles.

Most of the skeleton in these creatures showed reptilian features. In particular, the hinge of the lower jaw with the upper jaw, which is a determinant in zoological and palaeontological classification, was that of a reptile. The skull, however, had a palate and teeth like those of a mammal, and the back of the skull hinged on the backbone by two knobs as in mammals. The joints in all four feet were arranged as in mammals. The backbone was like that of a dog in that the vertebrae could turn slightly (enabling the animal to lie down on its side, something no other reptile was ever able to do). Furthermore the attachments of the ribs to the backbone show that the ribs themselves could be moved to allow regular breathing controlled by a diaphragm as in mammals.

All in all, we know that at that time there were hairy reptiles, with warm blood and furry coats. Among these were obviously the ancestors of the mammals, of which Phascolotherium *was a very early European example.*

conditions in the organism's environment as has sometimes been suggested. There is a regular rate for mutation: though slow, it resembles reshuffling a pack of cards and thus provides the permutations and combinations that give rise to variation and so, in many cases, to evolution.

Obviously in animals which reproduce sexually there will be a set of chromosomes from each parent in the fertilized egg, and quite a number of recombinations are possible. Each recombination will produce its own effect. Sex, for example, is determined by the x and y chromosomes. Two x's give a female; xy a male, though this is sometimes reversed as in birds and butterflies. Other combinations determine the colour of hair and eyes and all other physical attributes. Certain genes are dependent on environmental factors for their effects; familiar examples are the effects of temperature on changes in fur or feather colour.

Adaptations are among the most complex heritable factors and can be of value to the particular organism in enabling it to survive and have the maximum number of offspring, thus helping the species to survive, or there may be an association of adaptations between males and females, or between insects and plants, for example, whereby each depends largely on the other for existence and survival. Mimicry and pollination are results of this kind.

Natural selection takes place in nature without man's aid or intervention. It is, by definition, the effect of natural causes working on a population showing heritable variation. This eventually produces remarkably important results. It leads to those individuals in a population which become best adapted to their environment having a larger number of descendants—and these descendants are capable, of course, of further adaptation and thus of still greater probability of survival. This is really what the unfortunate phrase "survival of the fittest" means. (The subtitle of *The Origin of Species* is in fact, "or the preservation of favoured races in the struggle for life".) Natural selection is also important in that although variation is random, selection makes it adaptive and the process then *appears* to be intentional or directed.

In brief, the evolution of animals and plants comes about through the variation in them caused by the mutation and recombination of genes, the success of the variation being determined by natural selection. This results in changes in populations. If these changes are continued and if, for example, geographical isolation or other factors, including the members of the population's own divergences, preclude them from interbreeding, then these forms may become new and separate species.

WHEN did evolution become generally accepted?

Charles Darwin worked consistently from 1842 until 1858 in his attempts to solve the problems of variation and the origin of species. Then one day in June 1858 the postman brought a bulky envelope to him at Down House, Downe, near London, England. The envelope contained an essay by Alfred Russel Wallace, who was far away at Ternate in the Moluccas, and Wallace asked Darwin's opinion on it.

Darwin saw that Wallace had studied the same problems but had found an apparent answer. He realized he had been forestalled. Hurried conferences with fellow scientists led him to prepare a digest of his views and this digest, and Wallace's paper, were both read at a special meeting of the Linnean Society of London on July 1, 1858. No one paid much attention to these papers.

However, Darwin was stimulated to condense his vast series of notes into a book and this, *The Origin of Species by means of natural selection*, was published in November, 1859. It caused a great stir. Much of the comment was controversial and Darwin was a reluctant adversary, leaving most of the defence to Thomas Henry Huxley.

The merit of both Charles Darwin's work and that of Wallace is that they show the *reason* for the phenomena as well as giving many examples. The idea of the influence of Natural Selection came to both of them, quite separately, after reading *An Essay on Population*, published in 1798 by the Rev. T. R. Malthus.

While the accumulation of facts in *The Origin of Species* is enormously impressive the work suffers from a lack of knowledge of genetics. Darwin thought that characters were inherited equally from the parents and were blended into intermediacy, and this mistake is reflected in some of his arguments. The fault is understandable for there was then no science of genetics. The fundamental work was just being done by Gregor Johann Mendel (1822–1884) an Augustinian monk at Brno in Moravia who made some remarkable studies in cross-breeding pea plants in the monastery garden. By the time he was made abbot of the monastery in 1868, he had established what we now call the Mendelian law of dominant and recessive characters and the principle of the inheritance of single characters. Thus he could show that while parents did contribute equally to the offspring, the characters were not blended but remained distinct and gave natural selection time to work slowly and yet effectively. The weakness of Darwin's theory was rectified. The work was published by Mendel in 1866. Darwin died in 1882, Mendel in 1884 and the obscure paper that founded the science of genetics was not discovered until 1900. Since that time the verdict of scientists has been overwhelmingly in favour of the acceptance of the fact of evolution and its explanation by means of natural selection working upon random variation.

Why is evolution important?

When Charles Darwin visited the Galapagos Islands in 1835 he was astonished at the varieties of birds. The finches for example, though essentially true to their type elsewhere, had adaptations of beak, tail and claws that made them fill many niches in the environment. It was here that he realized that, given opportunity and freedom from competition, it was possible for considerable adaptation to take place.

Men have recognized something of this potentiality, by breeding. This can be called artificial selection and every gardener, horse or dog lover knows it well. When we consider what the horticulturists have done and can do, when we consider the fact that all dogs, from Chihuahua to St. Bernard, are derived from the one kind of ancestral dog, and when we consider the variety of horses that not long ago was familiar to us from carthorse to the sleek racehorse, then we must realize the importance of deliberate selection that emphasizes certain traits that are heritable. While birds, cows, horses and dogs are the most familiar of the specially bred stocks, perhaps the most important economically are the plants, especially the cereals. The varieties of grain, such as barley, rye and wheat have enormously increased since the process of genetic inheritance was recognized. We are apt to forget that these are self-seeding plants which have to shed their seeds widely in nature if they are to survive. For man's purpose the ripened grains should not be easily shed and spread, and the breeding of a stiffer stalk is therefore important as well as an increased yield.

Much of the success of modern farming depends upon mechanisms discovered through the study of evolution. If all plants and animals had remained precisely the same throughout history, agriculture would be very different from what it is today.

Recent examples of artificial selection are the breeding in numbers of black mink in Canada and the development in Mexico of spineless cactus for use as cattle food.

The knowledge of the laws of genetics coupled with the remarkable discoveries in the chemistry of the gene and especially of the nucleic acids make it certain that in the years to come new techniques in breeding, in the alteration and removal of genetic patterns, will be possible, with immense possibilities in medicine and surgery.

The elephant did not therefore get its trunk by having its nose pulled by the crocodile, as Rudyard Kipling engagingly wrote, but by belonging to a series of animals in which the face got consistently longer until it outgrew its support and fell down as a trunk. And the giraffe's neck was not attained because generations of giraffes stretched at the almost forbidden fruits in high trees. Generations of giraffe ancestors with a genetic tendency to length of neck and leg bred the animal as we know it now. The effects of use and disuse are not inherited, although Darwin included them, among others, in his list of causes. Blacksmiths do not necessarily have muscular children and most one-legged men breed children with the usual pair.

Truth can be stranger, and much less simple, than fiction.

SUGGESTED READING

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